SPORES OF THE GENUS SELAGINELLA IN NORTH AMERICA NORTH OF MEXICO

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In 1901 L. M. Underwood remarked that the old *Selaginella rupestris* was one of several examples in which segregation of species had "successively expanded to the bounds that would cause the botanists of twenty years ago to suffer acute paralysis." Among American workers Underwood had already started this segregation three years earlier. The critical studies of Van Eseltine (1918), Maxon (1918, 1920, 1921), and most recently of Weatherby (1944, 1946) have added further new species. Additional collections and critical study will no doubt bring to light still other new species. Dr. Maxon has noted the need for an examination of the species complexes *S. densa* and *S. Wallacei.*

The spores, particularly the characters of the megaspores, have appeared to be an integral part of recent descriptions of species. Mr. Weatherby has expressed the opinion that when used cautiously the pattern of spore sculpture is useful in species definition. The present study was undertaken to present a survey and an illustrated account of the spores of our native Selaginellas.

The megasporangia are not very generously supplied with spores, each usually containing but four megaspores. Each spore has a hemispherical base and three plane triangular faces. The base or *outer face* is the free surface in the tetrad and the three plane triangular surfaces—collectively, the *commissural face*—are the sides in contact in the tetrad. The commissural face is marked by three prominent *commissural ridges* which are united at the apex and radiate out at nearly equal angles to the vicinity of the *equator*. The ends of the ridges are sometimes connected by an *equatorial ring*.

The spore surface may be smooth, granular, rugose, rugose-reticulate, or tuberculate wholly or in part. The enclosed areas in a reticulate pattern are called *areolae*. The photographs convey the type of sculpture more accurately than a descriptive statement, and, unless remarks on variations accompany the data for each species, the illustrations can be regarded as representative of the material examined.

It rarely happens that one or two of the megaspores within a sporangium may develop at the expense of the others, which are then much dwarfed. The megasporangium of *S. rupestris* usually bears two spores although occasionally three or a single spore may develop. The spores of this species characteristically lack commissural ridges but some spores bear a single straight or circular ridge. Occasionally sporangia contain one or two peculiar "dumb-bell"-shaped spores in which there has been an incomplete division (Lyon, 1905). One megasporangium of *S. pilifera* was observed to have eight megaspores.

The size of the megaspores range from 0.15 mm. in diameter in *S. armata* to 0.53 mm. in *S. selaginoides*. The measurements given in the text are of the

greatest diameter. The mode is used to express the central position of the measurements. It is printed in italic between the extremes.

The color of the spores was determined at 45 diameters, using natural light and a black background. The color range is expressed according to Ridgway's 'Color Standards.' The popular term of color approximately equivalent to that of Ridgway's is in parentheses. There is marked variation in color in some species, immature spores often being of a different shade than the mature spores.

The megasporangium was removed from the strobilus and soaked in 50 per cent alcohol. After two or three minutes it was sufficiently pliable to dissect out the spores. Some care had to be used to prevent them from escaping for they were easily blown or jarred from the dissecting field after the alcohol dried. The spores were mounted dry, on a glass or mica slide, within a ring of cement built up to support the cover glass, and this was sealed with cement.

The megaspores were photographed through a compound microscope using a 48-mm. microteliplat lens as the objective and a 15 × hyperplane lens as an ocular. Additional magnification was achieved through suspending a 10 × ocular above the microscope. The camera, a Bausch & Lomb Model K, with 8-inch bellows, was placed over this. An image in focus at the third lens was also in focus on the ground glass of the camera. Four Leitz microscope lamps with green filters were placed around the microscope at the level of the stage. These supplied a very satisfactory source of illumination, for the intensity and angle of the light could be adjusted for each lamp. The film used was Eastman Ortho-X, and the exposure time varied from 20 to 90 seconds.

Each microsporangium bears several hundred microspores which are borne in tetrads and have the same shape as the megaspores and are sculptured in essentially the same manner. The commissural face usually is marked with three commissural ridges although some have a single ridge. The spores of some species have a prominent wing at the equator. The surface of the microspores also bears distinctive markings such as spines, tubercules, or rugae, but it is difficult to find and to recognize mature material. Photographs of the microspores are included when they are representative and show good detail for the species. Twelve spores were measured for each species. The microspores of S. *rupestris* are similar to the megaspores in that they frequently lack the commissural ridges and an occasional dumbbell type is found.

The microspores are roughly about one-eighth as large as the megaspores, ranging from 23 μ in diameter in several species to 64 μ in S. *tortipila*. There is no definite correlation between the size of mega- and microspores of the same species. For example, S. *armata* and S. *selaginoides* have microspores of a similar size while the mode of the megaspores of the former is 0.19 mm. and that of the latter is 0.53 mm. A magnification of at least 400 diameters is necessary to study the surface detail of the microspores, and 70 or 80 diameters is desirable for examination of surface detail of the megaspores.

The microspores are generally more deeply colored than the megaspores, tending toward deep orange or red rather than the lighter yellows, although in some species, as S. *selaginoides*, both mega- and microspores are of the same color.

Slides were prepared by breaking open a microsporangium on a glass slide, adding a drop of lactic acid, and sealing the mount with ringing cement. A lactic acid preparation was more satisfactory than a dry mount, for sculpture not otherwise evident could be distinguished. H. W. Morris, photographer for the University of Minnesota Hospital, photographed the microspores. A homal 3-ocular and a 8-mm. objective were used with a 46-cm. bellows extension of the camera. Illumination was from a carbon arc lamp with a Kaisering green filter. Polychrome plates were used.

The collections studied, for the most part, were identified by such authorities on the genus as Maxon, Van Eseltine, Weatherby, and Wherry. Specimens were examined from the collections of the American Fern Society, Chicago Natural History Museum, Gray Herbarium, University of Minnesota, Missouri Botanical Garden, United States National Museum, and the University of Wisconsin. I wish to express my appreciation to the curators of the herbaria of these institutions who have so kindly lent material for study.

This study has been mainly done at the Missouri Botanical Garden where facilities were generously granted by the Director. The photography was done at the University of Minnesota and the costs incurred supported by the Department of Botany. The problem was initiated at the University of Wisconsin, where a study of *Selaginella* spores was presented as a master's dissertation. I am especially grateful to my husband for the preparation of the photographic unit for the megaspores and for the suggestions and aid given in the study.

Synopsis of Selaginella in North America North of Mexico

The following synopsis has been primarily adapted from the current literature, and references are given to the papers upon which it is based. Since there may be some question regarding the disposition of certain species, now generally reduced to synonymy, it was thought desirable to include photographs and discussion of the spores of these. Characters presented in the synopsis allow it to be used to a certain extent as a key. However, the characters are general ones relating to whole groups and are not necessarily without exception. Each species bears the same number in the text and plates as it does in the synopsis.

SUBGENUS EUSELAGINELLA[1]

Vegetative leaves uniform; sporophylls uniform.

Group of S. selaginoides. Strobilus cylindric..... 1. S. selaginoides (L.) Link

Group of S. rupestris. Strobilus tetragonous.

a. Stems typically erect, rooting only at the base.
b. Setae tortuous.

subgroup of s. tortipila..... 2. S. tortipila A. Br.
2. *S. Sherwoodii* Underw. (see Wherry, 1936)

[1] The subgenera, groups and series are taken from Walton and Alston (1938).

b. Setae straight.
SUBGROUP OF S. BIGELOVII. Megaspores rugose on the outer face.... 3. S. RUPINCOLA Underw.
4. S. CORYI Weatherby
5. S. BIGELOVII Underw.
6. S. NEOMEXICANA Maxon

SUBGROUP OF S. ARENICOLA. Megaspores smooth or very nearly so on the outer face..... 7. S. RIDDELLII Van Eselt.
8. S. ARENICOLA Underw.
8. S. *funiformis* Van Eselt. (see Clausen, 1946)
9. S. ACANTHONOTA Underw.
9. S. *floridana* Maxon (see Clausen, 1946)

a. Stems prostrate, rooting throughout.
c. Stems radially symmetrical.
SUBGROUP OF S. OREGANA. Stems elongate, slender, branches remote. (see Weatherby, 1944)..... 10. S. OREGANA D. C. Eaton
11. S. UNDERWOODII Hieron.
12. S. MUTICA D. C. Eaton
13. S. CINERASCENS A. A. Eaton

SUBGROUP OF S. RUPESTRIS. Stems short, stout, branches congested.. 14. S. WATSONI Underw.
15. S. STANDLEYI Maxon
16. S. LEUCOBRYOIDES Maxon
17. S. WALLACEI Hieron.
18. S. SIBIRICA (Milde) Hieron.
19. S. ASPRELLA Maxon
20. S. DENSA Rydb.
21. S. RUPESTRIS (L.) Spring
22. S. SCOPULORUM Maxon
23. S. WRIGHTII Hieron.

c. Stems strongly dorsiventral.
SUBGROUP OF S. HANSENI. Vegetative leaves uniform or nearly so.. 24. S. SHELDONI Maxon
25. S. HANSENI Hieron.

SUBGROUP OF S. PARISHII. Vegetative leaves dimorphous. (see Weatherby, 1943a)..... 26. S. ARIZONICA Maxon
27. S. EREMOPHILA Maxon

SUBGENUS STACHYGYNANDRUM

Vegetative leaves dimorphous, sporophylls uniform.

SERIES DECUMBENTES. Widely creeping, prostrate, stems rooting throughout..... 28. S. DOUGLASII (Hook. & Grev.) Spring
29. S. ARMATA Baker
30. S. APODA (L.) Fern. (*S. ludoviciana* A. Br.)

SERIES CIRCINATAE. Tufted xerophytes, ascendent, rooted only at the base.. 31. S. LEPIDOPHYLLA (Hook. & Grev.) Spring
32. S. PILIFERA A. Br. (*S. Pringlei* Baker—see Morton, 1939, and Weatherby, 1943b)

DESCRIPTION

SUBGENUS EUSELAGINELLA

GROUP OF S. SELAGINOIDES.—

1. S. SELAGINOIDES (L.) Link. Pl. 23, fig. 1.

Megaspores Barium Yellow (yellow, green-tinged); 0.48–*0.52*–0.53 mm. in diameter, 18 spores measured. *Microspores* Barium Yellow (yellow, green-tinged); 26–34 μ in diameter.

GROUP OF S. RUPESTRIS.—

SUBGROUP OF S. TORTIPILA.—

The two members of this group cannot be distinguished on the basis of spores. This would agree with Wherry's (1936) conclusion that S. *Sherwoodii* is merely an ecological form of S. *tortipila*. The megaspores of S. *Sherwoodii* in the collection examined are strongly tuberculate-rugose. Those of S. *tortipila* are of a similar pattern of sculpture and some are less prominently marked.

2. S. TORTIPILA A. Br. Pl. 23, fig. 2.

Megaspores Straw Yellow to Lemon Chrome (lemon-yellow); 0.25–*0.34*–0.41 mm. in diameter, 26 spores measured. Some spores are more prominently rugose on the outer face than in fig. 2b. *Microspores* Pinard Yellow (pale yellow); 41–64 μ in diameter.

2. S. *Sherwoodii* Underw. Pl. 23, fig. *2.*

Megaspores Apricot Yellow (pale orange); 0.32–0.40 mm. in diameter, 9 spores measured. Some spores are less prominently tuberculate-rugose on the outer face than in fig. *2b*. *Microspores* Apricot-Yellow (pale orange); 38–63 μ in diameter.

SUBGROUP OF S. BIGELOVII.—

Megaspores of S. *rupincola* show a marked variation in prominence of sculpturing. Fig. 3b represents an extreme phase with a well-marked equatorial ring. For the most part, the megaspores examined are sculptured to a less degree as illustrated in fig. 3a, but with a more strongly pronounced equatorial ring. Megaspores of S. *Bigelovii* examined are finely rugose and usually bear an equatorial ring. Some megaspores are marked with subechinate, lace-like prominences which can be seen along the margins of the spores illustrated.

Commissural face of megaspores with moderately coarse rugae; outer face rugose to rugose-tuberculate, ridges low and crowded, areolae narrow if present..... 3. S. RUPINCOLA
Commissural face of megaspores with fine rugae; outer face with low, obscure rugae, areolae small, scarcely distinct from the low, rounded ridges.. 5. S. BIGELOVII

3. S. RUPINCOLA Underw. Pl. 24, fig. 3.

Megaspores Apricot Yellow (pale orange); 0.19–*0.29*–0.34 mm. in diameter, 29 spores measured. *Microspores* Deep Chrome (bright orange); 38–64 μ in diameter.

4. S. CORYI Weath. Am. Fern Jour. 36:51–53. 1946.

Spores of this species were not available for photography but two megaspores from the TYPE have been examined. They are rather similar to those of S. *rupincola* except that they lack an equatorial ring. They are about 0.4 mm. in diameter and Apricot Yellow (pale orange). The rugae are prominent on the outer face and there are distinct areoles between the rugae.

5. S. BIGELOVII Underw. Pl. 24, fig. 5.

Megaspores Apricot Yellow (pale orange); 0.25–*0.34*–0.40 mm. in diameter, 49 spores measured. *Microspores* Apricot Yellow (pale orange); 38–49 μ in diameter.

6. S. NEOMEXICANA Maxon.

Megaspores unknown.

SUBGROUP OF S. ARENICOLA.—

The members comprising this group are difficult to distinguish on the basis of the spores. Clausen (1946) has recognized three species and remarked that of these S. *arenicola* and S. *acanthonota* are not wholly separable. The commissural face is more strongly marked than the outer face in all of the species. However, the sculpturing is rather variable and there appears to be no marked character which distinguishes the species except the degree of prominence of the sculpturing.

The megaspores of S. *Riddellii* are more strongly marked on the outer face than those of the other species. In the collections studied the megaspores of S. *acanthonota* are as prominently rugose-reticulate on the commissural face as those of S. *Riddellii*, and phases of sculpture on the megaspores of S. *acanthonota* and S. *arenicola* are indistinguishable.

Megaspores rugose on outer face	7. S. RIDDELLII
Megaspores smooth on outer face.	
Scarcely rugose on the commissural face	8. S. ARENICOLA 8. S. *funiformis*
Rugose to rugose-tuberculate on commisural face	9. S. ACANTHONOTA 9. S. *floridana*

7. S. RIDDELLII Van Eseltine. Pl. 24, fig. 7.

Megaspores Lemon Chrome (lemon yellow); 0.21–*0.32 & 0.38*–0.46 mm. in diameter, 16 spores measured. The outer face is usually more prominently rugose than in fig. 7b. *Microspores* Apricot Yellow (pale orange); 34–53 μ in diameter.

8. S. ARENICOLA Underw. Pl. 24, fig. 8.

Megaspores White to Apricot Yellow (pale orange); 0.25–*0.29*–0.42 mm. in diameter, 35 spores measured. The outer face is smooth or minutely punctate. *Microspores* Apricot Yellow to Deep Chrome (pale to bright orange); 34–47 μ in diameter.

8. S. *funiformis* Van Eseltine. Pl. 25, fig. *8.*

Megaspores Straw Yellow to Pinard Yellow (pale yellow); 0.21–0.34 mm. in diameter, 6 spores measured. The spores examined are similar in pattern of marking to those of S. *arenicola* but are of a deeper yellow. *Microspores* Deep Chrome (bright orange); 30–41 μ in diameter.

9. S. ACANTHONOTA Underw. Pl. 25, fig. 9.

Megaspores White to Lemon Chrome (lemon yellow); 0.29–*0.36*–0.42 mm. in diameter, 28 spores measured. The pattern of sculpture is similar but the degree of prominence varies between that represented in fig. 9a and 9b. *Microspores* Deep Chrome (bright orange); 34–45 μ in diameter.

9. S. *floridana* Maxon. Pl. 25, fig. *9.*

Megaspores White to Lemon Chrome (lemon yellow); 0.19–*0.32*–0.40 mm. in diameter, 36 spores measured. *Microspores* Deep Chrome (bright orange); 32–53 μ in diameter.

SUBGROUP OF S. OREGANA.—

The group of S. *oregana* as treated by Weatherby (1944) includes several Mexican species and is characterized on the basis of habit. The spores of the species treated here are all distinct and do not appear to indicate relationships between the species.

a. Commissural face of megaspore more prominently rugose than outer face, commissural ridges connected by equatorial ring or free.
  b. Commissural face delicately rugose, commissural ridges thin and delicate.
    c. Outer face slightly reticulate, meshes forming small areolae scarcely more distinct than those of the commissural face..... 10. S. OREGANA
    c. Outer face strongly reticulate, meshes forming broad, shallow areolae more distinct than those on the commissural face..... 11. S. UNDERWOODII
  b. Commissural face coarsely and remotely rugose, commissural ridges broad and coarse; outer face lightly rugose to smooth..... 12. S. MUTICA
a. Commissural face of megaspores lightly rugose, less prominently sculptured than outer face, commissural ridges connected by a prominent, thin equatorial ring..... 13. S. CINERASCENS

10. S. OREGANA D. C. Eaton. Pl. 25, fig. 10.

Megaspores Pinard Yellow (pale yellow); 0.27–*0.32*–0.36 mm. in diameter, 25 spores measured. Some spores bear cross ridges connecting the commissural ridges. *Microspores* Pinard Yellow (pale yellow); 41–56 μ in diameter.

11. S. UNDERWOODII Hieron. Pl. 26, fig. 11.

Megaspores Apricot Yellow (pale orange); 0.27–*0.36*–0.42 mm. in diameter, 38 spores measured. *Microspores* Deep Chrome (bright orange); 30–45 μ in diameter.

12. S. MUTICA D. C. Eaton. Pl. 26, fig. 12.

Megaspores Apricot Yellow (pale orange); 0.21–*0.29*–0.42 mm. in diameter, 31 spores measured. Some spores bear an equatorial ring; some are more strongly rugose-reticulate than fig. 12a. *Microspores* Apricot Yellow (pale orange); 30–53 μ in diameter.

13. S. CINERASCENS A. A. Eaton. Pl. 26, fig. 13.

Megaspores Pinard Yellow (pale yellow); 0.32–*0.37*–0.38 mm. in diameter, 16

spores measured. *Microspores* Apricot Yellow (pale orange); 38–53 μ in diameter.

SUBGROUP OF S. RUPESTRIS.—

The subgroup of S. *rupestris* includes the largest number and the most perplexing species of the subgenus. Several of the species are undoubtedly aggregate groups which need to be extensively collected and critically examined. Maxon (1920, 1921) has investigated some of these and has remarked on relationships between them, but for the most part a natural series has not been worked out.

There is a remarkable similarity between the pattern of sculpture of the megaspores of some of the species. The megaspores of S. *asprella* and one phase of the megaspores of S. *densa* cannot be distinguished. However, there is much variation in the spore sculpture between collections of S. *densa*. Some collections of S. *Watsoni* have megaspores scarcely rugose and very similar in pattern to those of S. *Standleyi;* others have prominently marked spores rather like those of S. *scopulorum*. The megaspores of S. *Wallacei* are variously sculptured but frequently characterized by an equatorial ring.

a. Megaspores 4 per sporangium; 3 commissural ridges.
  b. Outer face obscurely rugose-reticulate to nearly smooth.
    c. Commissural face finely rugose-reticulate ..... 14. S. WATSONI
      15. S. STANDLEYI
    c. Commissural face with coarse, low rugae ..... 16. S. LEUCOBRYOIDES
  b. Both faces strongly rugose to rugose-tuberculate.
    d. Commissural face with coarse, remote rugae; outer face strongly reticulate, surface of the areolae broad and smooth ..... 19. S. ASPRELLA
      20. S. DENSA
    d. Commissural face with delicate, compact rugae; outer face with areolae small or scarcely apparent.
      e. Commissural face strongly rugose to rugose-reticulate; nearly all rugae on outer face joined in a net forming areolae of moderate size.
        f. Equatorial ring usually present ..... 17. S. WALLACEI
        f. Without equatorial ring ..... 14. S. WATSONI
          18. S. SIBIRICA
          22. S. SCOPULORUM
      e. Both faces with prominent flexuose rugae which have free ends, areolae narrow if present ..... 23. S. WRIGHTII
a. Megaspores 2 per sporangium; commissural ridges lacking or a single ridge present ..... 21. S. RUPESTRIS

14. S. WATSONI Underw. Pl. 26, fig. 14.

Megaspores Apricot Yellow (pale orange); 0.27–*0.40*–0.50 mm. in diameter, 75 spores measured. The commissural ridges are usually straight and the commissural face somewhat less prominently sculptured than fig. 14a. *Microspores* Deep Chrome (bright orange); 30–53 μ in diameter.

15. S. STANDLEYI Maxon. Pl. 27, fig. 15.

Megaspores Apricot Yellow (pale orange); 0.34–*0.40*–0.48 mm. in diameter, 24 spores measured. Some spores are more prominently rugose than fig. 15. *Microspores* Apricot Yellow (pale orange); 26–41 μ in diameter.

16. S. LEUCOBRYOIDES Maxon Pl. 27, fig. 16.

Megaspores Apricot Yellow (pale orange); 0.32–0.47 mm. in diameter, 8 spores measured. *Microspores* Flame Scarlet (red orange); 38–56 μ in diameter.

17. S. WALLACEI Hieron. Pl. 27, fig. 17.

Megaspores Apricot Yellow (pale orange); 0.27–*0.34*–0.38 mm. in diameter, 51 spores measured. Some spores are less prominently sculptured than fig. 17, and some are without an equatorial ring. *Microspores* Deep Chrome (bright orange); 38–49 μ in diameter.

18. S. SIBIRICA (Milde) Hieron. Pl. 27, fig. 18.

Megaspores Pinard Yellow to Apricot Yellow (pale yellow to pale orange); 0.38–*0.40*–0.42 mm. in diameter, 5 spores measured. The commissural ridges are usually twice as long as those in fig. 18a. *Microspores* Deep Chrome (bright orange); 38–49 μ in diameter.

19. S. ASPRELLA Maxon. Pl. 28, fig. 19.

Megaspores Straw Yellow to Apricot Yellow (pale orange); 0.29–*0.34*–0.38 mm. in diameter, 6 spores measured. Some spores have an equatorial ring. *Microspores* Pinard Yellow to Deep Chrome (bright yellow to bright orange); 34–53 μ in diameter.

20. S. DENSA Rydb. Pl. 28, fig. 20.

Megaspores Apricot Yellow (pale orange); 0.36–*0.40*–0.50 mm. in diameter, 48 spores measured. The spores photographed are from type material and illustrate the pattern of sculpture in several of the collections studied. *Microspores* Deep Chrome (bright orange); 34–49 μ in diameter.

21. S. RUPESTRIS (L.) Spring. Pl. 28, fig. 21.

Megaspores Deep Chrome (bright orange); 0.32–*0.46*–0.53 mm. in diameter, 53 spores measured. The sculpture of the spores examined is generally of the same pattern, varying in the prominence of reticulation. *Microspores* Apricot Yellow (pale orange); spores monolete, 49–75 μ in greatest dimension.

22. S. SCOPULORUM Maxon. Pl. 28, fig. 22.

Megaspores Deep Chrome (bright orange); 0.32–*0.42*–0.48 mm. in diameter, 35 spores measured. *Microspores* Apricot Yellow (pale orange); 34–56 μ in diameter.

23. S. WRIGHTII Hieron. Pl. 29, fig. 23.

Megaspores Apricot Yellow to Deep Chrome (pale to bright orange); 0.18–*0.25*–0.55 mm. in diameter, 44 spores measured. There is considerable variation in size of spores of this species, since one large spore may develop at the expense of three small spores within a megasporangium. The pattern of sculpture of the spores is generally similar. *Microspores* Deep Chrome (bright orange); 34–56 μ in diameter.

SUBGROUP OF S. HANSENI.—

The two species of this subgroup are allied on the basis of strongly dorsiventral stems and uniform leaves. The spores are distinctive for each species.

Commissural face of megaspores without equatorial ring; strongly reticulate on outer face ..... 24. S. SHELDONI
Commissural face of megaspores with prominent equatorial ring; lightly rugose on outer face ..... 25. S. HANSENI

24. S. SHELDONI Maxon. Pl. 29, fig. 24.

Megaspores Deep Chrome (bright orange); 0.34–*0.36*–0.44 mm. in diameter, 28 spores measured. *Microspores* Deep Chrome (bright orange); 34–45 μ in diameter.

25. S. HANSENI Hieron. Pl. 29, fig. 25.

Megaspores Lemon Chrome (lemon yellow); 0.29–*0.36*–0.42 mm. in diameter, 40 spores measured. *Microspores* Apricot Yellow (pale orange); 38–49 μ in diameter.

SUBGROUP OF S. PARISHII.—

Two members of this group are Mexican and are not treated here. The megaspores of S. *eremophila* are for the most part more prominently sculptured than the megaspores of S. *arizonica*. In both species a single, large megaspore and three small spores may be found within a sporangium.

Commissural face of megaspore finely rugose-reticulate; scarcely marked with equatorial ring; outer face coarsely reticulate to smooth ..... 26. S. ARIZONICA
Commissural face of megaspore with sharp, projecting rugae, prominent equatorial ring; outer face deeply rugose-reticulate ..... 27. S. EREMOPHILA

26. S. ARIZONICA Maxon. Pl. 29, fig. 26.

Megaspores Apricot Yellow (pale orange); 0.25–*0.32*–0.46 mm. in diameter, 36 spores measured. Some spores are more prominently marked than fig. 26b; some have an obscure equatorial ring. *Microspores* Deep Chrome (bright orange); 23–38 μ in diameter.

27. S. EREMOPHILA Maxon. Pl. 29, fig. 27.

Megaspores Pinard Yellow (pale yellow); 0.23–*0.34*–0.50 mm. in diameter, 25 spores measured. *Microspores* Deep Chrome (bright orange); 38–53 μ in diameter.

SUBGENUS STACHYGYNANDRUM

The species included in this study belonging to this subgenus are all characterized by strikingly distinct spores. The microspores are as strongly marked as the megaspores. The microspores of S. *apoda* and S. *Douglasii* have a pebbled appearance, those of S. *armata* are beset with papillae and those of S. *pilifera* have globules of a waxy substance adhering to them.

SERIES DECUMBENTES.—

Megaspores less than 0.22 mm. in diameter; deep yellow to orange; obscurely rugose to nearly smooth ..... 29. S. ARMATA
Megaspores more than 0.36 mm. in diameter; straw-yellow or lighter with a green-tinge; strongly marked.
  Megaspores granular to tuberculate ..... 28. S. DOUGLASII
  Megaspores marked with prominent, thin, free rugae ..... 30. S. APODA

28. S. DOUGLASII (Hook. & Grev.) Spring. Pl. 30, fig. 28.

Megaspores Straw Yellow; 0.36–*0.38*–0.40 mm. in diameter, 7 spores measured. *Microspores* Deep Chrome (bright orange); 23–41 μ in diameter.

29. S. ARMATA Baker. Pl. 30, fig. 29.

Megaspores Deep Chrome (bright orange); 0.15–*0.19*–0.21 mm. in diameter, 15 spores measured. *Microspores* Flame Scarlet (red orange); 26–34 μ in diameter.

30. S. APODA (L.) Fern. Pl. 30, fig. 30.

Megaspores Barium Yellow (yellow, green-tinged); 0.34–0.36 mm. in diameter, 7 spores measured. *Microspores* Flame Scarlet (red orange); 23–34 μ in diameter.

SERIES CIRCINATAE.—

Megaspores spinulose	31. S. LEPIDOPHYLLA
Megaspores granular	32. S. PILIFERA

31. S. LEPIDOPHYLLA (Hook. & Grev.) Spring. Pl. 30, fig. 31.

Megaspores Deep Chrome (bright orange); 0.23–*0.29*–0.42 mm. in diameter, 23 spores measured. *Microspores* adhere in tetrads which are Flame Scarlet (red orange).

32. S. PILIFERA A. Br. Pl. 30, fig. 32.

Megaspores Straw Yellow to Pinard Yellow (pale orange); 0.25–0.29 mm. in diameter, 11 spores measured. Some spores have an equatorial ring. *Microspores* Flame Scarlet (red orange); 26–38 μ in diameter.

BIBLIOGRAPHY

Baker, J. G. (1887). Handbook of the fern allies. London.

Broun, M. (1938). Index to North American ferns. Orleans, Mass.

Clausen, R. T. (1946). *Selaginella,* subgenus Euselaginella, in the southeastern United States. Am. Fern Jour. **36**:65–82.

Hieronymus, G. (1900). Selaginellarum species novae vel non satis cognitae. I. Hedwigia **39**:290–320.

Lyon, F. M. (1901). A study of the sporangia and gametophytes of *Selaginella apus* and *Selaginella rupestris.* Bot. Gaz. **32**:124–141, 170–194.

———, (1905). The spore coats of *Selaginella. Ibid.* **40**:285–295.

Maxon, W. R. (1918). A new *Selaginella* from Oklahoma and Texas. Proc. Biol. Soc. Wash. **31**:171–172.

———, (1920). New Selaginellas from the western United States. Smithson. Misc. Coll. **72**[5]:1–10.

———, (1921). Notes on American ferns—XVII. Am. Fern Jour. **11**:34–39.

———, (1923). Notes on American ferns—XIX. *Ibid.* **13**:73–75.

Morton, C. V. (1939). Our southwestern resurrection plants. *Ibid.* **29**:14–16.

Reeve, R. M. (1935). The spores of the genus *Selaginella* in north central and north eastern United States. Rhodora **37**:341–345.

Ridgway, Robert (1912). Color standards and color nomenclature. Washington, D. C.

Selling, O. H. (1946). Studies in Hawaiian pollen statistics. Pt. I. Bishop Mus. Spec. Publ. 37.

Underwood, L. M. (1898). *Selaginella rupestris* and its allies. Bull. Torrey Bot. Club **25**:125–133.

———, (1901). A changed conception of species. Fern Bull. **9**:49–53.

Van Eseltine, G. P. (1918). The allies of *Selaginella rupestris* in the southeastern United States. Contr. U. S. Nat. Herb. **20**:159–172.

Walton, J., and A. H. G. Alston (1938). Lycopodiinae in Verdoorn, Manual of Pteridology, pp. 503–506.

Weatherby, C. A. (1943a). The group of *Selaginella Parishii.* Am. Fern Jour. **33**:113–119.

———, (1943b). Selaginellaceae, in Johnston, I. M., Plants of northern Mexico, I. Jour. Arn. Arb. **24**:325–329.

———, (1944). The group of *Selaginella oregana* in North America. *Ibid.* **25**:407–419.

———, (1946). A new *Selaginella* from western Texas. Am. Fern Jour. **36**:51–53.

Wherry, E. T. (1936). Observations on *Selaginella tortipila.* Jour. So. Appalach. Bot. Club **1**:65–69.

Explanation of Plate

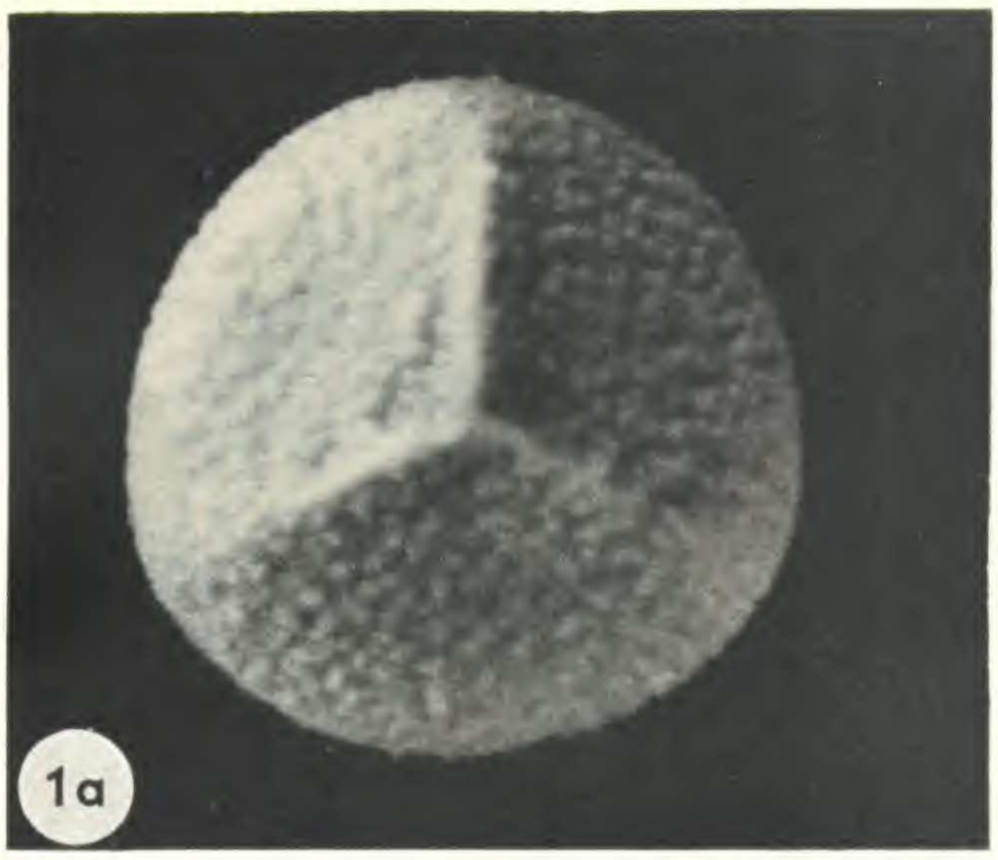
In this and the following plates, which are reproductions of photographs, the magnification for the megaspores is 85 diameters and for the microspores 450 diameters.

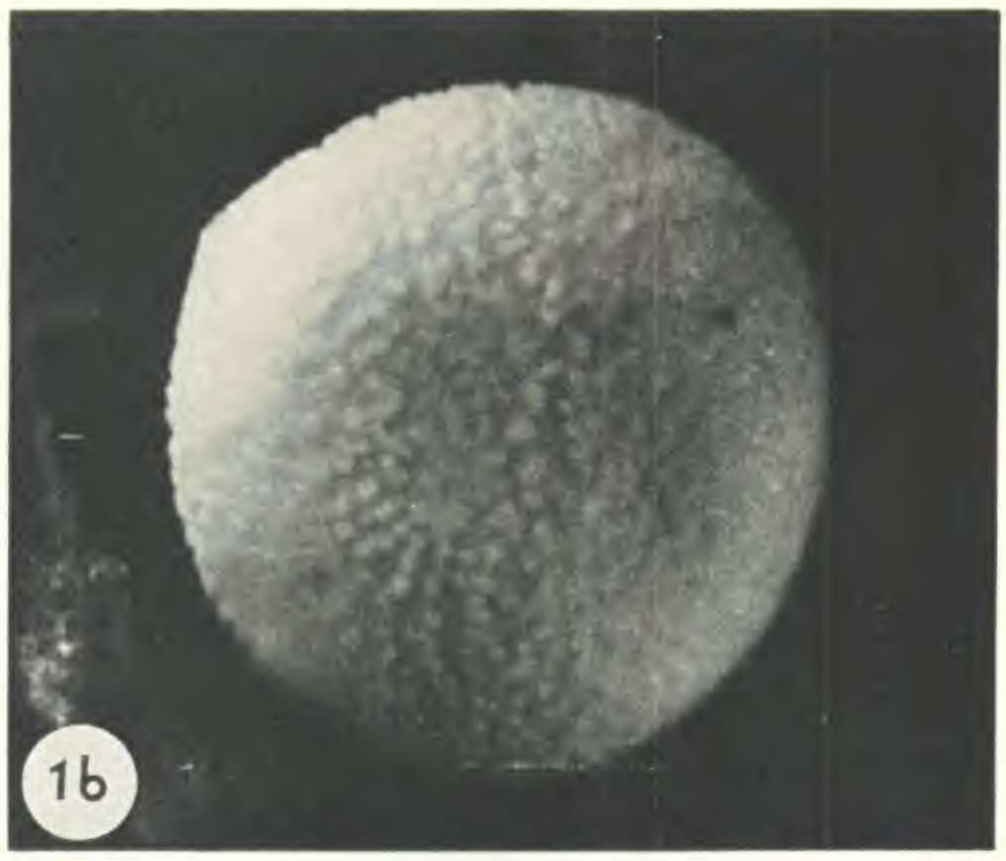
PLATE 23

Fig. 1. S. SELAGINOIDES: *Butters & Holway*, Alberta, 1905 (Univ. Minn.). 1a. Commissural face of megaspore. 1b. Outer face of megaspore.

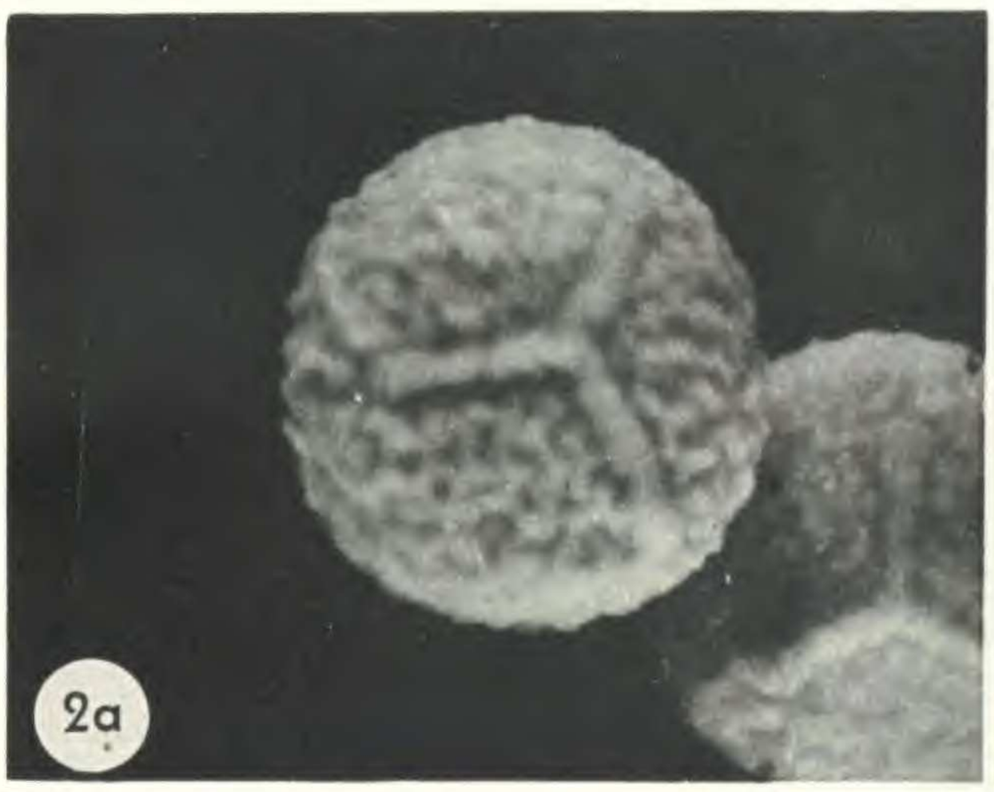
Fig. 2. S. TORTIPILA: *Donnell-Smith*, South Carolina, 1881 (Chicago Nat. Hist. Mus.). 2a. Commissural face of megaspore. 2b. Outer face of a moderately marked spore.

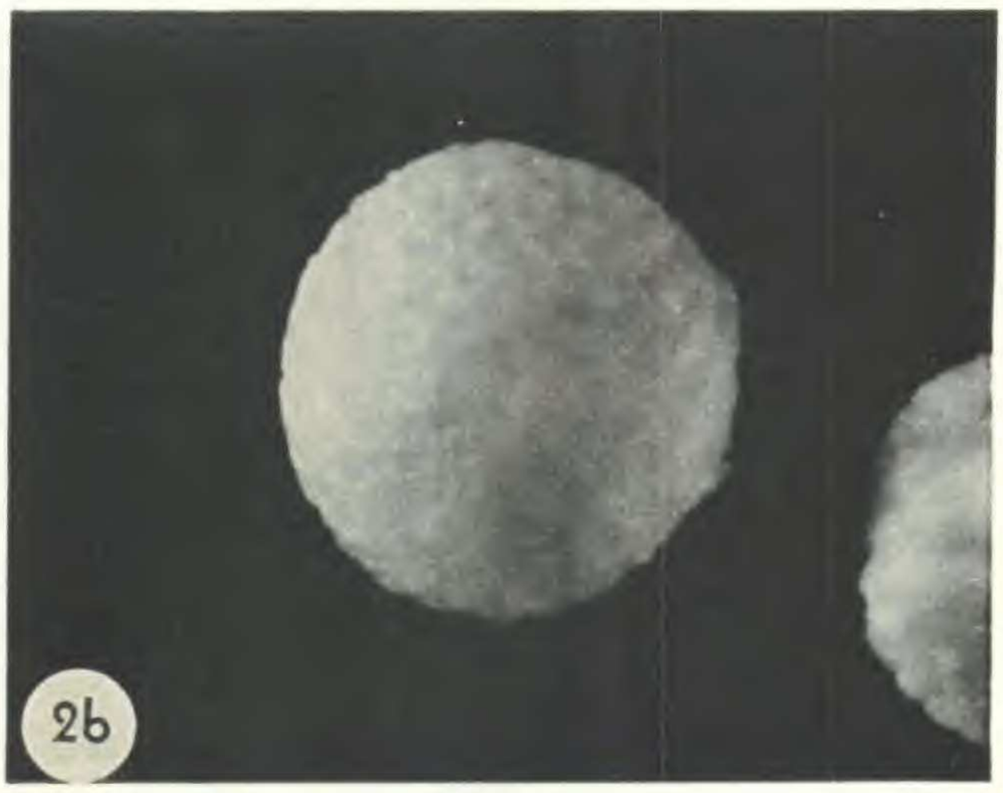
Fig. *2*. S. *Sherwoodii: Donnell-Smith*, North Carolina, 1882 (Mo. Bot. Gard.). *2a*. Commissural face of megaspore. *2b*. Outer face of a strongly marked megaspore. *2c*. Microspore.





S. SELAGINOIDES

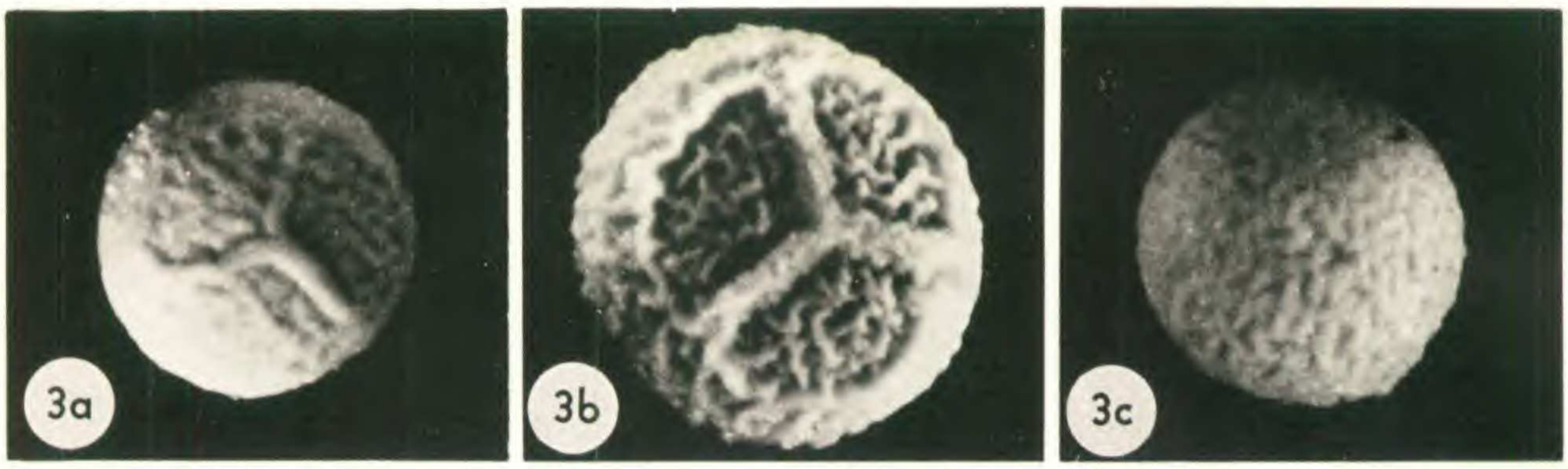




S. TORTIPILA

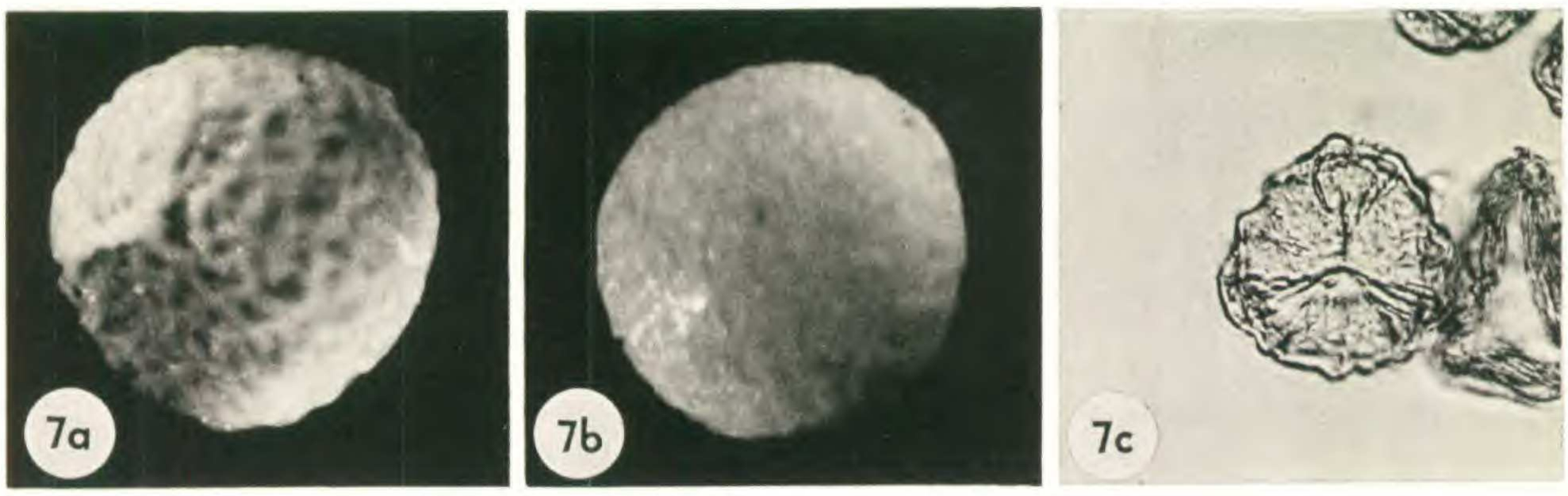
S. Sherwoodii

TRYON — SELAGINELLA SPORES



S. RUPINCOLA

S. BIGELOVII



S. RIDDELLII

S. ARENICOLA

Explanation of Plate

PLATE 24

Fig. 3. *S.* RUPINCOLA: 3a. Commissural face of megaspore, *Goodding*, Arizona, 1921 (Chicago Nat. Hist. Mus.). 3b. Commissural face of prominently sculptured megaspore, *Wooton*, New Mexico, 1907 (Univ. Minn.). 3c. Outer face of megaspore, from the same specimen as 3a.

Fig. 5. S. BIGELOVII: 5a. Commissural face of megaspore without prominent equatorial ring, *Rose 34495*, California, 1932 (Chicago Nat. Hist. Mus.). 5b. Outer face of megaspore, *Grant & Wheeler*, California, 1904 (Univ. Minn.). 5c. Microspore from the same specimen as 5a.

Fig. 7. S. RIDDELLII: *Cory 41099*, Texas, 1943 (Gray Herb.). 7a. Commissural face of megaspore. 7b. Outer face of a lightly marked megaspore. 7c. Microspore.

Fig. 8. S. ARENICOLA: *Deam 63923*, Florida, 1946 (Mo. Bot. Gard.). 8a. Commissural face of megaspore. 8b. Outer face of megaspore. 8c. Microspore.

Explanation of Plate

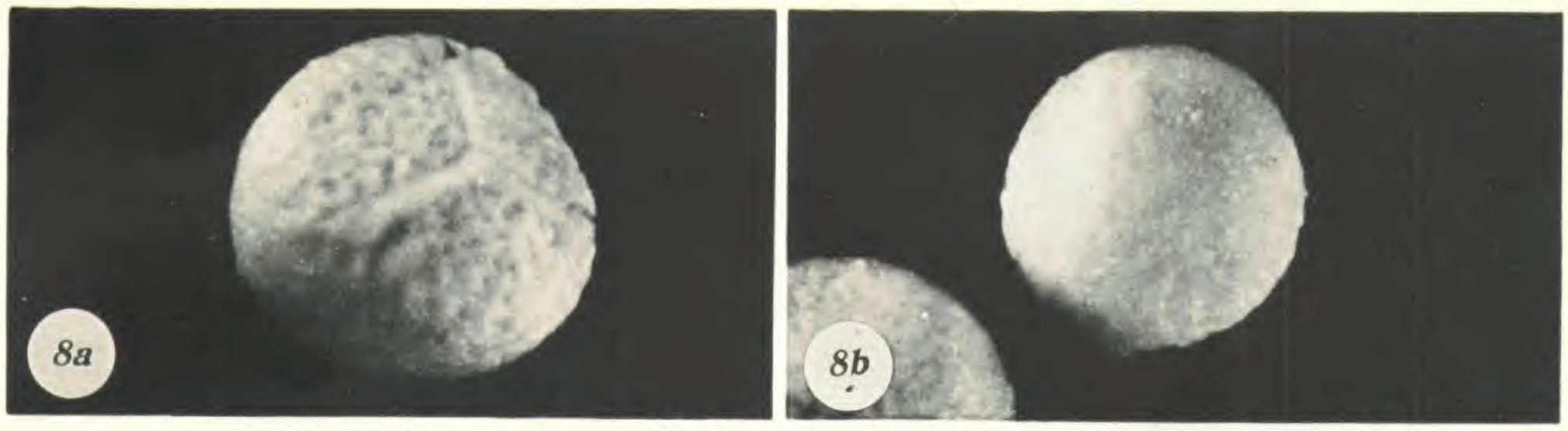
PLATE 25

Fig. *8*. S. *funiformis: O'Neill 7580*, Florida, 1933 (Chicago Nat. Hist. Mus.). *8a*. Commissural face of megaspore. *8b*. Outer face of megaspore.

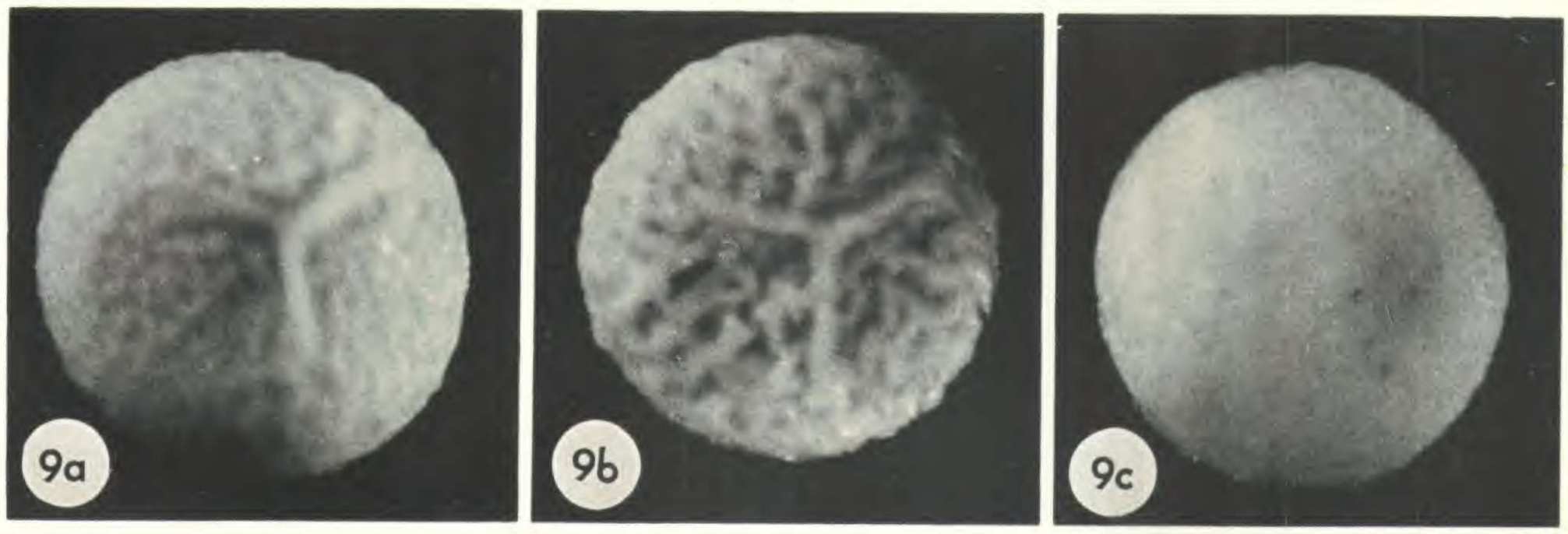
Fig. 9. S. ACANTHONOTA: 9a. Commissural face of a lightly marked megaspore, *Pyron & McVaugh 3101*, Georgia, 1938 (Mo. Bot. Gard.). 9b. Commissural face of a prominently marked megaspore, *Harper 1957*, Georgia, 1903 (Mo. Bot. Gard.). 9c. Outer face of megaspore, from same specimen as 9a.

Fig. *9*. S. *floridana: Nash 1449*, Florida, 1894, Isotype (Chicago Nat. Hist. Mus.). *9a*. Commissural face of megaspore. *9b*. Outer face of megaspore.

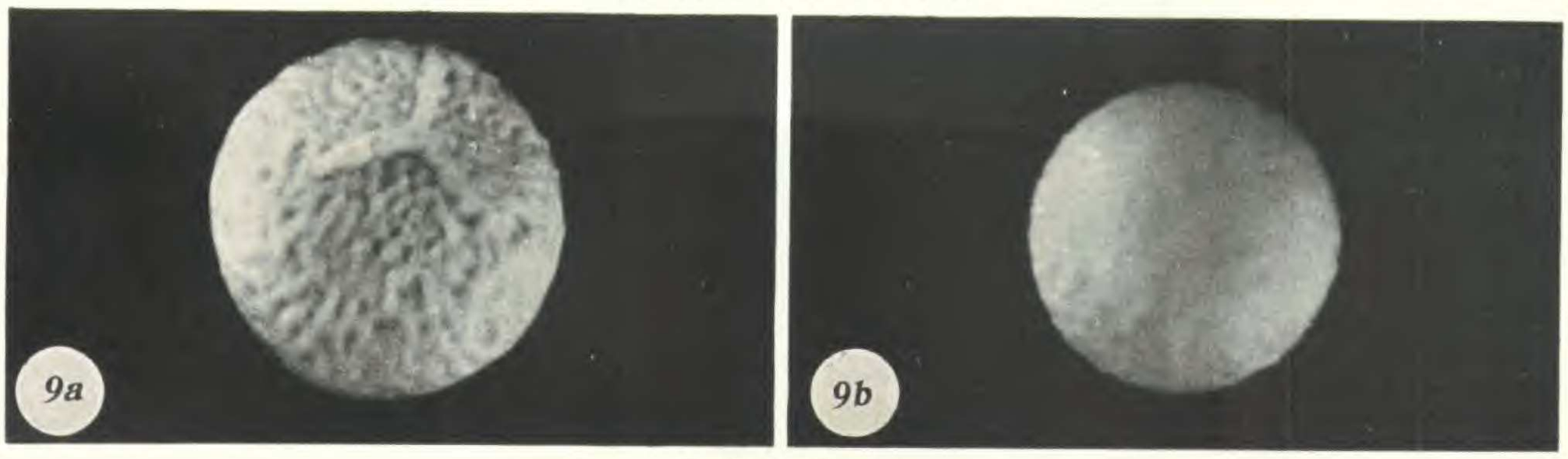
Fig. 10. S. OREGANA: *Piper*, Washington, 1893 (Univ. Minn.). 10a. Commissural face of megaspore. 10b. Outer face of megaspore. 10c. Microspore.



S. funiformis



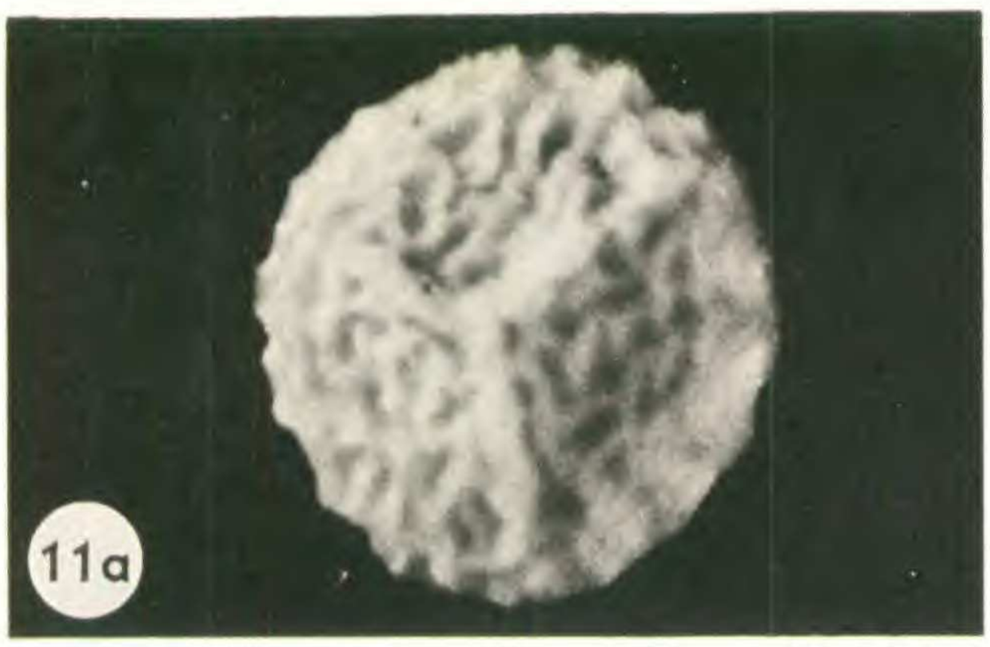
S. ACANTHONOTA



S. floridana

S. OREGANA

TRYON — SELAGINELLA SPORES



S. UNDERWOODII

S. MUTICA

S. CINERASCENS

S. WATSONI

TRYON — SELAGINELLA SPORES

Explanation of Plate

PLATE 26

Fig. 11. S. Underwoodii: 11a. Commissural face of megaspore (var. *dolichotricha* Weath.), *Metcalfe 991*, New Mexico (Mo. Bot. Gard.). 11b. Outer face of megaspore, *Clark 8968*, Arizona, 1940 (Mo. Bot. Gard.).

Fig. 12. S. mutica: *Drouet, Richards & Rubinstein 4097*, Colorado, 1941 (Mo. Bot. Gard.). 12a. Commissural face of a lightly marked spore without an equatorial ring. 12b. Outer face of megaspore. 12c. Microspore.

Fig. 13. S. cinerascens: *Abrams 3399*, California, 1903 (Chicago Nat. Hist. Mus.). 13a. Commissural face of megaspore. 13b. Outer face of megaspore.

Fig. 14. S. Watsoni: *Maguire, Hobson & Maguire 14729*, Utah, 1936 (U. S. Nat. Herb.). 14a. Commissural face of a prominently marked megaspore with unusual flexuose commissural ridges. 14b. Outer face of megaspore. 14c. Outer face of megaspore with large areolae. 14d. Microspore.